range in such environments is not the critical component and is typically compensated for by providing additional base stations to service the area.

Thus, having an upper threshold of "thermal noise floor + 65 dBm" would considerably increase the utilization (+60 %) of the UPCS band and decrease infrastructure costs for high capacity installations.

Conclusion

The present "upper threshold" is too low. When the AWS H-Block begins to be actively used a single H-Block device may block the entire UPCS band with the current "upper threshold". Further, the current level effectively prevents using the band in dense usage scenarios, which otherwise could be effectively serviced by UPCS devices. The utilization of the UPCS band is limited to 60 % less than its potential. The upper limit should be increased to TN + 65 dB.

Because it believes it has identified a useful improvement of the monitoring threshold contained in 47CFR15.323(c)(5) ANSI ASC C63 SC7 is pleased to present this petition to the FCC and looks forward to continued dialogue with the Commission as it seeks to support and optimize the utility of the UPCS band.

Respectfully submitted,

ANSI ASC C63 SC7

Mr. Stephen Berger
Chair, ANSI ASC C63 SC7

TEM Consulting, LP
140 River Rd.
Georgetown, TX 78628

(512) 864-3365

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Annex II

IEEE Std 1900.2 Annexes D & E

Annex D

(informative)

Sample analysis—selection of listen-before-talk threshold

D.1 Executive summary

[NOTE—The reason for this example:

This sample analysis demonstrates the pivotal importance an early assumption can make in an analysis. In this example the analysis is seeking to determine the optimum value for a threshold in a listen-before-talk, least-interfered channel protocol. The frequently, and often unstated, assumption is that range is the parameter to be optimized. However, density of devices in some use cases is a more important variable than range. The issue becomes, is range or density of devices more important? If range is selected as the principle value, a threshold of 20 dB less will be selected, than that which would be selected if density of devices were given the highest value.

This example also shows management of interference vs total avoidance of interference. In this case a far greater density of devices can be supported if a higher threshold is allowed. However, the densely populated devices would lose range during times of high use, necessitating additional base stations to support the entire population. If it can generally be assumed that densely located devices will normally be under the control of a single organization, then the organization that is receiving the benefit of the densely populated devices will also bear the cost of additional base stations. Thus the tradeoff becomes a network administrative issue and should be left to be optimized by the network administrator rather than be given a fixed value. If the installation of additional base stations is deemed a reasonable cost for the value of being able to support a high density of devices, then the higher threshold would be a reasonable choice. However, that conclusion depends on the validity of the assumption that in the vast majority of cases densely populated devices will be controlled by the same organization.

Alternately, a regulating authority may require some further protections that a single organization control exists before allowing a relaxed threshold. In a policy defined implementation, the regulator could allow the network administrator to adjust the threshold under certain conditions could be met. For example, the network administrator or in an automated implementation, the device or network, could determine if all the densely populated devices were under the control of the same network and only in that case allow the higher population density. So if one organization wanted to put a device in every cubical and the control logic could confirm this, then a more relaxed threshold could be allowed. If the local devices were under the control of differing organizations, then the logic could be required to utilize a lower threshold.]

In systems that use a listen-before-talk, least-interfered-channel protocol, there is a defined monitoring threshold above which transmission is not allowed. Before a unit is allowed to transmit, it is required to listen to its desired transmission channel. If the unit senses energy above the defined threshold, it is required to either wait for that channel to clear or move to a different transmission channel.

An example of such a protocol is given in the FCC rules for the Unlicensed Personal Communications Services band. The relevant sentence of 47CFR15.323(c)(5) [B8] reads as follows:

> *(5) If access to spectrum is not available as determined by the above, and a minimum of 40 duplex system access channels are defined for the system, the time and spectrum windows with the lowest power level below a monitoring threshold of 50 dB above the thermal noise power determined for the emission bandwidth may be accessed.*

The issue is as follows:

> What is the optimum value for the monitoring threshold, set in this FCC rule at 50 dB above the thermal noise power? Stated alternately, what is the best compromise between range and density of devices?

This analysis will show that the FCC selection of a threshold at 50 dB above the thermal noise is a credible choice when optimizing for range. However, to optimize for density of devices, a threshold of as much as 70 dB above the thermal noise yields better results.

D.2 Findings

This analysis will demonstrate that although a monitoring threshold of 50 dB above thermal noise is valid, assuming range is the primary issue. A value of 70 dB is justified so as to also support dense installations. The analysis argues that in almost all cases densely populated devices will be under the control of a single organization, which should be afforded the option of optimizing range versus density of base stations to meet the needs of its network.

D.3 Scenario definition

D.3.1 Study question

This analysis is being performed to support the setting of a monitoring threshold in a listen-before-talk, least-interfered-channel etiquette. The analysis is seeking to find a means for supporting densely populated devices.

D.3.2 Benefits and impacts of proposal

Many organizations have workers located in densely packed cubicles. When it is desirable to equip those workers with similar wireless devices, e.g., cordless phones or wireless headsets, the density of devices can exceed the available channels, creating an access problem during high usage periods. By raising the monitoring threshold, a greater density of devices can be supported. The cost is that devices further from a base station will receive interference from other devices and lose effective range. However, if the monitoring threshold allows the greater density of devices, the access issue can be addressed by installing additional base stations. Therefore, the situation becomes a network planning issue. The primary benefit of this analysis is that it preserves for an organization the option of installing a denser population of devices.

D.3.3 Scenario(s)

The scenario being analyzed is that created by a listen-before-talk, least-interference-channel spectrum etiquette.

D.3.3.1 Frequency relationships

Of the frequency relationships, only the in-band, co-channel relationship is considered. The threshold being analyzed only affects the frequency reuse decision for co-channel devices. It is assumed that other requirements give adequate protection for adjacent channel and out-of-band devices.

NOTE—In this sub-section, a matrix reduction step is combined with the analysis of frequency relationships. The analyst demonstrates awareness of other frequency relationships, such as adjacent channel and out-of-band devices but states a conclusion that these are not relevant for this scenario).

D.3.3.2 Usage model

Three usage models will be considered in this analysis. The first and baseline case is a single lightly populated installation where maximum range is desired. This baseline case will be compared with a second case where a single densely populated system is operating under the control of a single entity. A third case is that of multiple-entity operating systems in close proximity, such as in an office or apartment building.

Although some use scenarios should be optimized for distance, in other use scenarios, it is preferable to subordinate range for density of devices. In some use models, it is preferable that several devices are able to operate in close proximity, and density of devices is preferable to range.

There are situations where it is desirable to have a number of devices operating in close proximity. An example of such an operating environment would be a cubicle (partitions between offices that do not fully extend to the ceiling of the building) office environment where every cubicle might have a wireless device in it. In such a scenario, each device would lose range due to the density of spectral use. However, in such dense systems, it is common practice to install a system in which devices may operate a short distance from the nearest base station, and in this way, the loss of range has little if any effect.

D.3.3.3 Characteristics of usage models

The three use cases are assumed to share the following characteristics:

a) There is a listen-before-talk, least-interfered-channel requirement for all the devices.

b) There is a 10 MHz wide frequency band and devices with emissions bandwidth of slightly less than 2 MHz. Hence, there are 5 available transmit frequencies.

c) The devices operate under a protocol similar to DECT. The DECT transmission protocol uses TDMA techniques with symmetrical TX and RX timeslots on a 24 timeslot frame, 12 TX slots and 12 RX slots in each frame.

The equipment being used is assumed to be typical home or office devices, primarily telephones or wireless headsets. The usage is assumed to be to support typical office or home telecommunications services.

D.3.3.3.1 Spatial and power limits

The devices are assumed to be operating under relatively low power requirements, between 10 mW and perhaps 300 mW. Devices may be located arbitrarily, and the devices are mobile.

D.3.3.3.2 Temporal limits

It is assumed for this analysis that the band uses a 10 mS frame. It is also assumed that a device is required to monitor a channel for 1 frame period, 10 mS, and find it clear before it can use the channel.

It is then assumed that at maximum loading, the devices are in use 70% of the time; that is that the probability of any one device being used at a given time is 70%. It is also assumed that while in use, each device transmits data in every time slot available to it.

In most cases it is sufficient if remedies can be provided on a temporary basis in minutes and on a permanent basis in a few days.

D.3.3.3.3 Frequency characteristics

As stated in D.3.3.3, the systems are assumed to operate in a 10 MHz wide frequency band and each of the devices has an emissions bandwidth of slightly less than 2 MHz. There are, therefore, 5 available transmit frequencies.

D.3.3.3.4 Other orthogonal variables

No other orthogonal variables are critical to this analysis.

D.3.3.4 System relationships

D.3.3.4.1 Systems considered

The systems are assumed to be systems operating according to the requirements of the band. For this analysis, other characteristics do not impact the analysis.

D.3.3.4.2 Protection distance

A protection distance of 0.4 m is selected for this analysis. The basis for this protection distance are use cases, such as a tight cubical environment or users on public transportation. In such environments, users may be only 0.6 m apart. Therefore, an individual user should be able to separate two devices at least 0.4 m apart. Even where the devices are being used by different, adjacent users, normally a 0.4 m separation may be arranged with relative convenience.

D.3.3.4.3 Geographic area for analysis

This analysis is assuming relatively low power devices, operating between 10 mW and 300 mW. The geographic area for analysis is line of sight and obstructed line of sight as determined by the operating power. The maximum operating range considered is 1000 m with a focus on operation under 500 m.

D.3.3.4.4 Impact of interference

For the cases under study, the only impact of interference is that a channel is not available to another system. Because all devices are operating in a listen-before-talk protocol, they will not impact each other once a device has gained the right to transmit on a channel. However, the threshold levels do affect which channels are available for use by other systems.

D.3.3.4.5 Interference mitigation

No interference with voice transmission or dropped calls is ever desirable. However, this analysis assumes that if there are temporary remedies available to the user within minutes and permanent remedies available, at reasonable cost, within days, then these are acceptable.

When a user experiences interference with a voice transmission, the following remedies are immediately available:

a) Move away from the interfering device.

b) Request that the interfering device be moved or its use discontinued.

c) Reinitiate the call; at which time, the system will probably locate a different frequency and time slot.

Beyond these temporary remedies, a permanent remedy is to install a higher density of base stations.

D.3.3.4.6 Baseline

The comparative context is the established 50 dB over thermal noise limit established with range as the primary objective. The analysis will study the impact of higher limits on range, density, and interference that exists for this baseline case.

D.3.4 Case(s) for analysis

There are then two cases for analysis, the in-band, co-channel interference for the baseline case and the case with an elevated threshold.

D.4 Criteria for interference

D.4.1 Interference characteristics

Interference that rises to the level of disrupting transmission is of primary interest. At that level of interference, data may be lost resulting in a number of effects. Although best-effort data service will require retransmission of the lost data, the largest impact will be on real-time services, e.g., a telephone call. Under the use scenario described, worst-case interference could create interference with voice calls due to lost packets. In the extreme worst case, calls could be dropped.

D.4.1.1 Impacted level

The impacted level for this case will be the received signal strength of the interfering signal.

D.4.2 Measurement event

The measurement event will be defined as one channel for one frame period. The frequency of each measurement event will be centered on a frequency channel and have a bandwidth equal to the transmission bandwidth, approximately 2 MHz. Each measurement event will last for one frame period, 10 mS.

D.4.3 Interference event

For the analysis, an interference event will be defined as a device being denied use of a channel it is monitoring for transmission.

D.4.4 Harmful interference criteria

It is proposed that harmful interference is deemed to occur if, under the worst-case loading of 70%, with devices spaced at 0.4 m, a device is unable to find an available channel or if a device would continuously transmit on a channel at a level that would cause audible interference for the user of another device.

D.5 Variables

The relevant variables are the monitoring threshold, distance, power, and time.

The contrasting variable is the monitoring threshold. All other variables are assumed to be identical.

D.6 Analysis—modeling, simulation, measurement, and testing

D.6.1 Selection of the analysis approach, tools, and techniques

This analysis is performed using fundamental calculations. It is believed that a more complex analysis is not required to explore the concept being examined. A number of variables, such as using a more complex propagation model or device usage model, are not included. However, for the purposes of this study, more complex analysis is not deemed necessary.

D.6.2 Matrix reduction

To simplify the analysis, the matrix of possible use scenarios will be reduced to a cubical environment with heavy voice usage of identical wireless devices, such as cordless phones or cordless headsets.

D.6.3 Performing the analysis

Simulations can be developed for high traffic density open areas (e.g., large office landscapes and exhibition halls with close to free space propagation). These simulations can show the impact of different monitoring thresholds on device density. Figure D.1 is a simulation of a system covering a three-floor 100 × 100 m building. There are 25 equally spaced base stations on each floor (20 m base station separation). The system has 60 duplex access channels (5 carriers with 12 duplex channels each) on a 10 MHz spectrum allocation. Moving portables, intracell and intercell handover are included in the simulation.

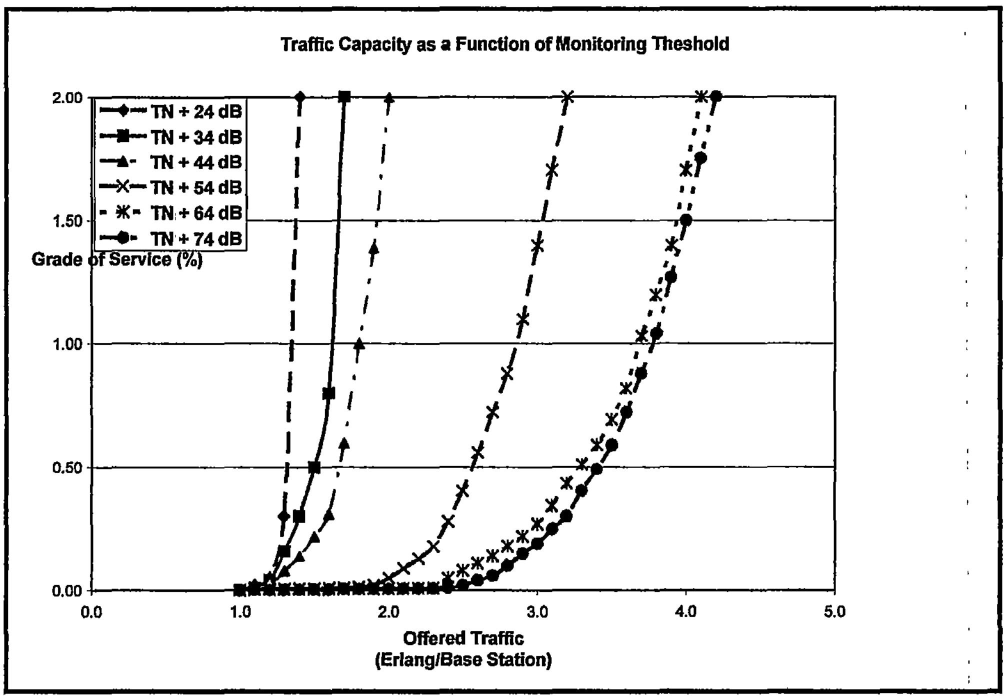

Figure D.1—Capacity as a function of the monitoring threshold limit (free space model of 120-system access channels)

Figure D.1 shows that for this specific simulation, the system capacity (1% grade of service limit) would increase by at least 60% if the monitoring threshold is changed from TN + 50 dB to TN + 65 dB.

For cases where access channels are relatively limited, it is even more important that an appropriate monitoring threshold be used. In such scenarios, devices have relatively few channels to which they can escape. In the example cited, the device has 5 frequencies available and 60 access channels. If the monitoring threshold is too low, it will restrict use of channels that are perfectly useful for communication. In dense usage environments, there would be a loss of range. However, range in such environments is not the critical component and is typically compensated for by providing additional base stations to service the area.

D.6.4 Quantification of benefits and interference

This analysis has been prepared to look and explore the impact the underlying assumption will have on establishing a listen-before-talk threshold. The insight gained may lead to more flexible protocols. If use environments can be identified by devices with sufficient certainty, then more appropriate thresholds might be allowed. In an environment where range is the primary concern, then a lower threshold would be used. However, in an environment where density of devices is the primary concern, a high threshold would be selected, trading density for range. The ultimate benefit would be to allow operation that is more appropriate for a specific use environment.

D.6.5 Analysis of mitigation options

The need for mitigation in an environment that focuses on range is primarily on the user of the device. When range is of primary interest, a lower threshold will be selected. This increases the possibility that few or no channels will be available to a device. The user of the device will then be presented from using the device, or its operation may be somewhat erratice, with it at times finding a qualifying channel in which to operate and at other times not finding one.

When the environment qualifies for density of devices, one entity has control of all the devices. This is a critical component of what qualifies an environment for density of devices. The entity, perhaps a company, can mitigate the loss of range by installing more base stations. It would not do this unless it found the benefit of having a number of devices operating in close proximity to justify the added expense.

D.6.6 Analysis uncertainty

This analysis is analytical, not experimental, and therefore, there is not measurement uncertainty. The primary uncertainty with an analytical analysis is that simplifying assumptions may not be valid. This is not believed to be the case in this analysis, but it could be true.

Additional uncertainty is introduced by not using a more realistic and complex use model. In reality some transmissions will not overlap in time and others will only partially overlap. On the boundaries, some transmissions will commence just as a device finishes its monitoring and prepares to transmit on a channel it believes to meet the threshold criteria.

D.7 Conclusion and summary

Thus, having an upper threshold of "thermal noise floor + 65 dBm" would considerably increase the utilization (+60 %) and decrease infrastructure costs for high-capacity installations.

D.7.1 Benefits and impacts

The primary benefit of implementing a higher threshold is that the number of simultaneous users would be increased greatly. The impact, beyond a loss or range, would primarily be in situations that were qualified to be optimized for density of users but in reality should not have been. An example would be a small office environment with different tenants operating separate systems in close proximity. One user may lose range due to the operation of a neighbor's system.

D.7.2 Summation

This analysis has demonstrated that if range is assumed to be the primary variable to be optimized when establishing a listen-before-talk threshold, the threshold may be set at a level that is lower than necessary. A more flexible approach will consider both range and density and may allow the use of multiple thresholds, if a means can be found to qualify environments for appropriate use of a threshold.

Annex E

(informative)

Sample analysis—effect of out-of-band emissions on a LBT band

[NOTE—This scenario is included as an example of how different spectrum management principles can affect each other, even across a band boundary.

This analysis is looking at the potential for interference in a very specific condition. How commonly this condition will exist is not examined. The structure of the analysis makes explicit how many limiting assumptions are being made, which is the value of the structure.]

E.1 Executive summary

The issue addressed in this analysis is the effect of an out-of-band emission limit on a nearby band using a listen-before-talk protocol. It demonstrates that if not carefully crafted, rules for different but adjacent bands can profoundly influence each other. In the case being considered, one band has a relatively typical out-of-band emission limit and an adjacent band is using a listen-before-talk protocol. The question is as follows: "How often could out-of-band emissions from one band block a device in the adjacent band from transmitting because its out-of-band emissions are above the threshold?"

E.2 Findings

What is found is that the out-of-band emissions from a single device has the potential for blocking the use of the first megahertz of the adjacent band for over 10 m and can block an entire 10 MHz band for over 3 m.

E.3 Scenario definition

E.3.1 Study question

The question being asked is as follows: "What is the effect of an out-of-band emission limit in one band on an adjacent band, using a listen-before-talk protocol?"

E.3.2 Benefits and impacts of proposal

The benefit of this analysis is to guide the more judicious crafting of rules so as to avoid interference to adjacent bands. The consequences could be to limit the spectrum management principles recommended for use adjacent to each other, to have more restrictive out-of-band emission limits, or raise the transmission threshold in a listen-before-talk band.

E.3.3 Scenario and usage model

Assumptions of this scenario are as follows:

a) Devices in both bands are assumed to be consumer products that can be expected to be used in close proximity to each other.

b) Typical use environments for these devices are offices, factories, and homes with typical separation distances of 1 m to 5 m.

c) The out-of-band requirement measures the allowed out-of-band emission using 1% of the transmit emission bandwidth filter in the first megahertz beyond the band edge and a 1 MHz bandwidth filter for frequencies beyond 1 MHz from the band edge.

E.3.3.1 Frequency relationships

This analysis looks at a single frequency relationship, the effect across a band boundary with one device transmitting and a device in the adjacent band, using a listen-before-talk protocol monitoring a channel in an attempt to transmit.

E.3.3.2 Usage model

A single usage model will be considered, two portable consumer devices, commonly used in close proximity to each other, such as in a home or office environment. An example would be a mobile phone and a cordless phone.

E.3.3.3 Characteristics of usage model

This usage model is characterized by two devices that are both portable. Both are assumed to be transmitting voice and so have real-time connectivity requirements.

E.3.3.3.1 Spatial and power characteristics

It is assumed that the devices may be used closer than 1 m from each other, such as in a cubical environment. How frequently two devices would be used in close proximity is not determined. It is assumed that this would be a reasonably common condition.

The two devices are assumed to have an unrestricted, line-of-sight condition to each other. It is recognized that architectural barriers may attenuate the signal of one device to the other. For this analysis, only the line-of-sight condition is treated.

NOTE—A matrix reduction step has been incorporated, limiting the analysis to only considering the condition when the two devices are used in close proximity and in a line-of-sight condition.

The transmitter, whose out-of-band emissions are being considered, is assumed to be a mobile phone with a transmit power of up to 2 W.

The analysis assumes an out-of-band transmit power of –13 dBm/MHz[37] would be permitted.

The interference level can be expressed as the equivalent level above Thermal Noise floor, TN. TN is –114 dBm for 1 MHz bandwidth.

Using the thermal noise floor as a reference, the assumed out-of-band emission limit of –13 dBm/MHz can be expressed as TN + 101 dB.

Within the first megahertz of the LBT band, the allowed out-of-band transmit power from a device in the neighboring band is –13 dBm/1% of B, where B is the bandwidth of the device transmission. If B = 1.25 MHz (as for CDMA 2000), the allowed interference becomes –13 dBm/12.5 kHz. TN is –133 for 12.5 kHz. Thus, –13 dBm/12.5 kHz can be expressed as TN + 120 dB.

In summary, the out-of-band emissions can be TN + 120 dB in the first megahertz and TN + 101 dB in the remainder of the band.

[37] –13 dBm/MHz is a value used in some frequency bands.

E.3.3.3.2 Temporal characteristics

This analysis is restricted to the condition where one device is transmitting and the recipient device is monitoring a channel in an attempt to transmit. How frequently this condition exists is not considered.

NOTE—A matrix reduction step has been incorporated, limiting the analysis to only considering the condition when one device is transmitting and the other is monitoring a channel in an attempt to transmit.

E.3.3.3.3 Frequency relationships

The transmitting device is assumed to be operating near the band edge. The listen-before-talk band is assumed to be 10 MHz wide, and the impact of the out-of-band emissions is considered on the entire band.

The purpose of this analysis is to evaluate the impact of an out-of-band emission limit, and so it is assumed that a transmitting device may be putting energy into the entire adjacent band at the level set by the limit.

NOTE—Two matrix reduction steps have been incorporated, limiting the analysis to only considering the condition when the transmitting device is near the band edge and further assuming that its out-of-band emissions are at the allowed limit over the entire adjacent band.

E.3.3.3.4 Other orthogonal variables

No other orthogonal variables are being considered.

NOTE—Yet another matrix reduction step is incorporated. Other variables are not considered, which may affect this situation, such as the degree to which the antennas on the two devices are cross polarized and how frequently intervening barriers will shield their transmissions from each other.

E.3.3.4 System relationships

E.3.3.4.1 Systems considered

The only system relationship being considered is that which exists between a typical mobile phone operating at 2 W across a band edge to a device monitoring a channel in an attempt to transmit. The characteristics of the devices are not relevant as this analysis is looking at the impact of the out-of-band emissions limit, which is common to all devices in one band, on the monitoring threshold, which is common to all devices in the adjacent band.

E.3.3.4.2 Protection distance

It is assumed that the two devices should be able to operate within 0.3 m of each other without impact.

E.3.3.4.3 Geographic area for analysis

The geographic area being analyzed is relatively close, within 10 m to 20 m. The devices being analyzed are low-power devices with limited transmission range. The source device is a higher power device with a potential range of a few kilometers.

E.3.3.4.4 Impact of interference

The impact of the interference is to deny the use of one or more channels to the listen-before-talk device.

E.3.3.4.5 Interference mitigation

In this scenario, the listen-before-talk device will monitor a different channel after finding one channel blocked. If all channels are blocked, it will not be able to transmit.

The interference could be remedied by moving the devices away from each other or waiting until one transmitting device stops transmitting.

E.3.3.4.6 Baseline

No baseline interference is assumed. This analysis is only looking at the additional impact from the single variable considered.

E.3.4 Case(s) for analysis

A single case is proposed for analysis. A mobile phone is assumed to be transmitting at 2 W in the channel nearest the band edge. In the adjacent band, a device is monitoring a channel, using a listen-before-talk (LBT) protocol.

E.4 Criteria for interference

E.4.1 Interference characteristics

Interference is characterized as energy that is gathered in to the recipient device while monitoring before transmission.

E.4.1.1 Impacted level

The impacted level is energy at the receiver input.

E.4.2 Measurement event

The measurement event is 1 channel bandwidth wide and 1 monitoring period in duration. That is, it is the monitoring period leading to a decision to transmit.

E.4.3 Interference event

An interference event is any measurement in which the threshold is exceeded and transmission denied. The monitoring threshold is assumed to be TN + 50 dB. Anytime the out-of-band emissions are above TN + 50 dB during a monitoring period will be considered an interference event.

E.4.4 Harmful interference criteria

If more than 10% of the band, 100 kHz, is blocked from use, it is proposed that harmful interference has occurred.

E.5 Variables

The relevant variables are as follows:

- Transmit power
- Out-of-band emissions limit
- Monitoring threshold
- Frequency separation
- Spatial separation

The only contrasting variable is spatial separation.

E.6 Analysis—modeling, simulation, measurement and testing

E.6.1 Selection of the analysis approach, tools and techniques

This analysis uses fundamental calculations to explore the question being addressed.

E.6.2 Matrix reduction

Of the possible cases for analysis, a single case is being considered. In this case, a higher power device, capable of transmitting up to 2 W, is operating near its band edge. The adjacent band is operating under a listen-before-talk, least-interfered-channel protocol. It is postulated that this scenario is worst case for the question addressed.

E.6.3 Performing the analysis

Assuming free-space propagation, the attenuation at 1 m, 3.2 m, and 10 m is about 38 dB, 48 dB, and 58 dB, respectively, for the 2 GHz frequency range. Table E.1 gives the interference levels experienced in the LBT band.

The interference power is expressed as the equivalent level above Thermal Noise floor, TN, for a transmitter with an out-of-band emission power of −13 dBm/12.5kHz in the first megahertz beyond the band edge and 13 dBm/MHz in frequencies more than 1 MHz from the band edge. This equates to an out-of-band emissions limit of TN + 120 dB in the first megahertz and TN + 101 dB in the remainder of the band.

Table E.1—Interfering power at different separation distances

Portion of the LBT band	Separation distance between TX devices and LBT band equipment		
	1 m	3.2 m	10 m
First megahertz	TN + 82 dB	TN + 72 dB	TN + 62 dB
>1 MHz from the band edge	TN + 63 dB	TN + 53 dB	TN + 43 dB

E.6.4 Quantification of benefits and interference

This analysis is performed to investigate a single aspect of interaction between dissimilar spectrum management methodologies. What is shown is that dissimilar methodologies may interact in undesirable ways even though each methodology is entirely acceptable in isolation.

E.6.5 Analysis of mitigation options

Few mitigation options are available for uses in the scenario being explored. The mitigation options are in the hands of spectrum managers and regulators, who have the ability to place compatible systems adjacent to each other.

E.6.6 Analysis uncertainty

Since this is an analytical analysis, there is no measurement uncertainty. There is considerable uncertainty as to the preliminary conclusions due to use of simple propogation and use models. The potential for interference, even very significant interference, has been identified. More complex analysis would be required to determine how frequently that interference would exist in more realistic use environments. This analysis proves that there is conceivable interference. Further exploration would be necessary to verify that this interference exists at higher levels of analysis.

E.7 Conclusion and summary

E.7.1 Benefits and impacts

Reviewing the interference levels of **Error! Reference source not found.** we find:

a) The first megahertz at the band edge is not usable with a monitoring threshold of less than 63 dB above thermal noise and loses a great deal of utility if the monitoring threshold is less than 72 dB.

b) If the monitoring threshold is set lower than 53 dB above thermal noise, a single transmitter potentially can block an entire neighboring band for a distance of 3 m to 10 m.

As can be seen in **Error! Reference source not found.**, out-of-band emissions requirements can have a significant impact on bands utilizing a listen-before-talk protocol. Unless the values of the monitoring threshold and the out-of-band emissions are carefully coordinated, there can be severe impacts on the utility of LBT bands.

E.7.2 Summation

This analysis has shown that significant interference is conceivable for the case examined. Where this possibility would become a reality requires further analysis using more realistic propagation and use model. Also of significance would be the possibility of identifying mitigations that may be available or reasonably made available to the users operating in such an environment.